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## THE UNDERGRADUATE PHYSICS CURRICULUM

A SYMPOSIUM on "The Undergraduate Physics Curriculum" was held under the joint sponsorship of Section F of the Ohio Academy of Science and the Ohio Section of the American Physical Society, at Miami University, Oxford, Ohio, April 7, 1951.

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## PHYSICS IN THE LIBERAL ARTS COLLEGE

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This is an inventory and an evaluation. It is a report of what we teachers of Physics in Ohio colleges think we should be doing. To find your opinions, and my own, I did not send out any questionnaires. If I had, I might have found out what we think we ought to think, but hardly what we do think. What we really think is written in the catalogues of our respective colleges under the heading COURSES IN PHYSICS. These are opinions on which we are prepared to act. In the case of Marietta College catalogue I should use the past tense. Whether anything else comes of this paper or not, the preparation of it has produced radical changes in my own thinking which will result in considerable revision of the next printing of our catalogue.

It is a well-known rule of investigation that it is easier to find answers if you have questions. In making this survey of opinions I examined the catalogues of forty Ohio colleges and sought answers to the following questions:

1. *Question.* What do we think is the main business of the college physics teacher?

*Answer.* The preparation of professional physicists (unanimous).

2. *Question.* What undergraduate work should be done by the future physicist?

*Answer.* Twenty-four to forty hours of physics and mathematics through calculus (90 percent of the schools). There is wide variation, however, in the timing of the mathematics. In some schools calculus must be taken concurrently with the first course in physics and some advanced courses have differential equations and advanced calculus as prerequisites. In a few schools, the entire physics sequence can be completed without going beyond trigonometry in mathematics.

3. *Question.* What kind of course should be offered to meet the "eight hours of physics" required for entrance to medical schools?

*Answer.* No special course (95%). Standard physics course with slight modifications (5%). Course specifically for premedical needs (none). In a

majority of the schools two introductory courses in physics are offered, one for "science" students and one for "arts" or non-science students. It is either stated or implied that the pre-medical students will take the non-science course. Usually this non-science course is described in negative terms. It is less mathematical, less laboratory, less in prerequisites.

4. *Question.* What responsibility have we to provide for the training of high school teachers of physics?

*Answer.* None (90%). Course in methods of teaching physics (10%).

5. *Question.* Should college physics courses take any recognition of work previously done in high school physics courses?

*Answer.* No (90%).

6. *Question.* Should courses be offered directly relating the methods, skills, and subject matter of physics to other sciences such as, chemical physics, geophysics, biophysics, psychophysics?

*Answer.* No (97%). In 10 percent of the schools there are, however, courses in laboratory arts such as glass-blowing and photography.

7. *Question.* Should courses in physics be offered directly relating the subject matter of physics to certain arts such as music and painting?

*Answer.* No (85%). The yes vote is largely due to courses in the physical theory of music. Some of these attempt to save face by using the title "acoustics."

8. *Question.* Should "how it works" courses be offered which deal directly with everyday gadgetry?

*Answer.* No (100%). A very few colleges offer courses in household physics and some of these may be directed toward the "how it works" goal.

9. *Question.* Is there any place for a course in physics whose primary goal is esthetic appreciation and personal orientation?

*Answer.* As a secondary goal, yes (25%). As a primary goal of the course, no (100%).

10. *Question.* Is the tremendous impact of physical science upon our culture a proper subject to be presented by a physicist?

*Answer.* No (100%), except that 5 percent of the colleges give courses in the history of physical science which are probably appropriate to this goal.

11. *Question.* Should courses be offered directly analyzing the methods of investigation used in physics?

*Answer.* Yes (10%). Another 10 percent give some course in which it is apparent that method of investigation is of primary concern and subject matter content is secondary.

From this survey I find that we are unanimous in the opinion that our main business is to train professional physicists. Our physics curricula are vertical: they are educational totem poles on which the arts and premedical students are the low men. Our horizontal extension is very limited. Perhaps it isn't physics, but the physicist has much in knowledge and understanding which would be valuable to students whose goal is not that of physics as a profession. We are doing little to make these available to such students.

Limitations of staff and facilities will make it impossible for most of us to do both. At present we are all doing the one thing, the vertical curriculum, and largely omitting the horizontal one. In looking at the great array of courses which we have set up for the training of professional physicists I am led to question whether the results are worth the cost. The cost in facilities and instruction time is large and the output small. Perhaps we would do a better job for our students and for physical science if we devoted a smaller part of our resources to producing physicists.

Here is a concrete proposal. The college I know best now offers 36 credit hours in the vertical sequence. Of these, 26 have calculus as a prerequisite. Why not cut this to 18 hours total made up of a first course of 12 hours with

calculus as a corequisite and an advanced course of 6 hours? This much with a strong supporting program can be completed by the student in his junior year. If he is one of those rare students whose interests and abilities point toward a career in physics he can transfer to a large college or university for his senior year. If circumstances prevent this he can still meet the minimum requirement for an "earn while you learn" program by finishing at his own school. The mathematics department gives a course in theoretical mechanics which is perfectly good physics. All that will be necessary will be to give this course a number in the physics department—double numbering is legal—and our student can have the 24 hours of physics credit needed for a civil service or other similar appointment.

In advocating this program of parsimony in training of physicists I do not have in mind de-emphasis of physics in the arts college but rather the expansion of the physics program. By this cut we have picked up 9 hours of teaching load per semester for doing other things. Physics is basic to every phase of life and we can use the time gained for enlarging the number of students that will include physics in their educational experience.

Later I shall have some more specific recommendations to make as to things that ought to be done with part of this instructional time but part of it, I urge, should be according to special interests of the instructor. The courses of this group should avoid any attempt to be respectable. The only prerequisite might be ability to read and write English. I think the courses should not be open to freshmen, as they should be mature in approach. Here is a list of such courses as occur to me. With them I have listed parenthetically the groups of students to whom they might appeal.

Music (musicians and tone-deaf music lovers)

Science Fiction (students of creative writing, psychology, and philosophy)

Color (artists, also women and most men)

Gadgets of Home and Office (students of home economics and any who expect to own or operate a home)

History of Physics or Philosophy of Physics (students of philosophy, of history, or anyone who likes civilization better than the other thing)

Manufacturing Processes (economics, and business administration majors)

Atomic Energy and Its Control (students of economics and political science and those who think survival is a good idea)

Generation and Use of Electric Power (students of economics and business administration)

The extent of this list is limited only by the imagination. The courses are not so worthy in themselves but will be profitable for the student if they are profitable for the professor. None of these is a must. Pick yourself one of wide appeal which would be fun for you.

There are other courses which are urgently needed. These are courses for training high school teachers of physics, for premedical education, and for application of physics to other sciences.

In Ohio, the training of high school physics teachers must become a matter of concern to us as individuals and as a professional group. We need to secure an increase in the requirements for the certification of teachers of physics so that they are equal to those for such fields as home economics, speech, and physical education. Since women are a majority among the high school teachers we need, for selfish reasons if for no other, to break down the prejudice against women as teachers of physics. As individuals we ought to find out more about the job of the high school teacher. Most of us are "old-fogey" in our ideas of secondary education. If we can get over this and approach the job realistically we ought to offer a course in teaching methods. If we cannot get rid of old prejudices sufficiently to create enthusiasm in the prospective teachers, we can at least give a course in making and contriving apparatus.

Pre-medical physics is in a worse state. Though the present day physician has more and more call to be a physicist in both the spirit of his approach and the equipment that he uses, the premedical physics remains feeble. Medical schools are shifting their administrative application of the "8 hours of physics" requirement to a perfunctory acceptance of whatever is offered. Students look upon the requirement as a foolish nuisance. From our catalogues it appears that this attitude is only a reflection of our own. Very few of us give any course which is calculated to have direct appeal to the pre-medical student. It is all very well to say that what the pre-medical student needs is straight physics but this does not solve the problem. I know you can quote a distinguished alumnus (physician) who says, "I didn't see it at the time, but I've been thankful you made me learn my physics." But what the student is going to say 15 years hence has little effect on his present attitude. There are text books and published reports to serve as a guide for any of us who wish to tackle the job. The point I want to make is simply that it is our job to so present physics to the premedical student that he sees its value and is interested. A few docile souls will study industriously on the assurance of some authority that they will later find value in what they are learning. The men who will become the medical scientists of the future are not of this frame of mind. If they can be really interested they may take more than the minimum of 8 hours of physics with us.

Akin to this problem of physics in relation to medicine is that of the other sciences. Not many years ago it was not uncommon for a student to complete a major in chemistry with little or no physics. That condition still exists in some schools, largely due to departmental rivalry. It has now come to be recognized that the chemistry major needs strong supporting courses in mathematics and physics. Improvement in the physics-for-chemists program can frequently be made if the physicist will go to the chemistry department with the simple question—what does the chemist want? The development of physics-for-biologists, physics-for-geologists, and physics-for-psychologists is at a much more elementary stage. It is an observable fact that a student's prospects of achievement in these fields are greatly enhanced by supporting study of physics. Mere requirement of physics for a major in those fields will accomplish little. We need to so contrive our choices of subject matter and method that the students will recognize the values in the physics department and elect our courses.

In conclusion, let me draw attention away from details to the one proposition, that we, as physicists, have a broad field of studies to occupy. I am not arguing for putting in required physics but rather for so exploring the interests and needs of students that they may be led to elect to study with us for a time. If this seems beneath the dignity of a physicist, I suggest a rereading of the life of Galileo.

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